

Network governance in low-carbon energy transitions in European cities: A comparative analysis

Abstract

This article evaluates the opportunities and limitations of network governance to support low-carbon energy transitions in European cities. Network visualization and statistical measures of network structure are combined with qualitative case study data to provide a comparative analysis of energy transition networks in Birmingham, Budapest and Frankfurt. Data reveal that existing networks differ in extent, integration and distribution of authority. Contextual characteristics help explain these differences, highlighting the importance of path dependencies and disjunctions in each city. These findings represent important considerations for the Transition Management model which aims specifically at governing sustainability transitions via network governance. Responding to a gap in the literature we demonstrate that Transition Management must be considered as an intervention into locationally specific settings and existing networks. The role of any 'transition manager' must also reflect existing network considerations. Failure to account for contextual differences limits the model's capacity to contribute to sustainable energy transitions in cities across Europe.

Keywords

Urban governance, network governance, transition management, energy transitions

1. Introduction

This article addresses the following question: To what extent does network governance provide a mechanism to support the transition to low-carbon energy in European cities? In recent decades cities have emerged as critical sites for facilitating climate action and global sustainability transitions (Bai et al., 2018; Bulkeley et al., 2015). However, despite the growing appetite to pioneer low-carbon development, the lack of capacity and capability within local authorities to catalyze and oversee low-carbon urban development remains a significant issue (Khan, 2013). Budgetary pressures and the privatization of assets and infrastructures have weakened the local public sector's ability to lead climate change mitigation and adaptation (Coutard, 2004; Hodson and Marvin, 2010a). In addition, the quest for economic growth and attracting investments typically override environmental concerns (Kern and Alber, 2009). This complex policy and organizational environment, coupled with growing pressure from the international community and grassroots citizen movements, has contributed to interest in developing and experimenting with novel coordination models in cities (Bulkeley and Castán Broto, 2013; Wittmayer and Loorbach, 2016). These initiatives are frequently designed and analyzed by using the concept of 'network governance' - systems of coordination that seek to guide and steer multi-actor interactions in order to solve complex public policy problems (Klijn and Koppenjan 2015) and its sub-set, Transition Management (TM). TM is a social coordination model aimed at rendering sustainability transitions *governable* (i.e. possible to govern) in polycentric social contexts where powers and responsibilities are dispersed among a range of actors with diverse interests (Loorbach, 2010; Nagorny-Koring and Nocht, 2018). TM-inspired initiatives spread to numerous cities within Europe (Roorda and Wittmayer, 2014; Wolfram and Frantzeskaki, 2016) and globally (Lachman et al., 2018).

Despite the widespread academic and policy application of network governance and TM to the sustainability policy agenda, two major issues need to be addressed. First, it is not obvious that network governance can be implemented in all European cities with the same (or sufficiently similar) approach(es) regarding extent, form and capacity to coordinate and steer. Concepts of network governance (and Transition Management) developed in one national context have often been applied to other settings without sufficient consideration of structural or cultural differences (Skelcher 2007) - these differences are likely to limit the analytical and normative power of the concepts. Secondly, the prescriptive orientation in the TM literature is predicated on the assumption that networks, once established, can be managed or steered to deliver more sustainable, low-carbon futures. If however the extent, form and capacity of network governance varies between European cities, then this has implications for the locally *appropriate* design and application of TM in particular settings in order to deliver impact. It therefore remains unclear whether these locally appropriate approaches can be assembled into a coherent TM governance model, or whether the model as it has developed so far has its limitations in terms of applicability in different geographical locations (cf. Broto, 2017; Lachman, 2013).

The two problems are analyzed in the following way. Section 2 discusses the literature on facilitating urban low-carbon transitions with an emphasis on the role of network governance and TM, and further examines the problems identified above. Section 3 introduces the research design and methods used to collect empirical evidence from three European cities: Birmingham (United Kingdom), Budapest (Hungary) and Frankfurt-am-Main (Germany). The analysis of the data is presented in section 4. Section 5 discusses the ways in which specific local contextual characteristics influence energy transition networks in the three cities. The results are used to answer the research question set out in the introduction, and to draw conclusions for the applicability of the TM model, in section 6.

2. Network governance and urban low-carbon transitions

Numerous studies have highlighted the multi-level and multi-actor character of governance settings relevant to governing and managing urban low-carbon transitions (Bulkeley et al., 2015; Khan, 2013). They contend that facilitating and delivering low-carbon transitions necessitates a systemic reorganization of contemporary societies, involving radical change to technological, institutional and cultural systems (Loorbach and Rotmans, 2010). Achieving this change requires coordinated action from actors operating within and between various organizations in multiple spatial levels and policy arenas. However, negotiating actors' diverse interpretations of the nature of the problems, the goals to be achieved, and the actions to be taken to achieve these, remains a challenge (Klijn and Koppenjan, 2015).

Network governance provides one solution. The term refers to the process of social coordination between public and private actors involved in public policy making and/or implementation, in which network relationships have an impact on substantive outcomes (Klijn and Koppenjan, 2012). Network governance is often considered as a third model of social coordination in addition to the traditional hierarchical (through the central position of the state) and the market (relying on competition between self-interested actors) options.

In contrast to hierarchies and markets, networks create space for interaction and multi-sectoral co-operation between various organizations; for facilitating informed decision-making based on knowledge exchange and deliberation between interdependent stakeholders; and for building engagement to achieve the negotiated goals (Klijn and Koppenjan, 2015). They are established, or tend to emerge organically, in 'institutional voids' (Hajer, 2003) and provide a semi-institutionalized context for interaction and negotiations.

The TM model explicitly aims at leveraging the potential of network governance to facilitate low-carbon transformations. TM is defined as

“a specific form of multi-level governance ... whereby state and non state actors are brought together to co-produce and coordinate policies in an iterative and evolutionary manner on different policy levels” (Kemp et al., 2007, p. 82).

It promotes a reflexive and participative approach aimed at harnessing the benefits of self-organization within and among 'transition arenas' - collaborative spaces around specific sustainability issues set up by 'transition managers' (Frantzeskaki et al., 2012; Nevens et al., 2013). Transition managers select arena participants and steer self-organizing processes within and between the arenas. The aim is to create the conditions for gradual change which, over a sufficiently long time period, is expected to lead to systemic, large-scale structural transition.

Many European cities have been experimenting with networked forms of governance to develop and deliver on sustainability targets for decades. Therefore, networks whose remit is relevant to low-carbon transition may exist in many cities. It nevertheless remains unclear how the existing networks influence the operation and success of the new, TM-backed decision-making arenas. There is a lack of knowledge about the potential and the options available to TM to influence existing network governance systems in specific real-world settings (Coenen and Truffer, 2012; Rutherford and Coutard, 2014). Further, the relationship between transition arenas involving private actors and existing state hierarchies is seldom discussed beyond the claim that TM is designed to complement traditional policy and decision-making. This is problematic as real-world networks must function in the shadow of traditional state hierarchies (Börzel, 2010). Vertical, hierarchical relationships are likely to exist among stakeholders involved in the transition arenas, too. Consequently, TM may

overestimate the benefits that network settings can offer for low-carbon transitions, but without sufficiently engaging with the conditions necessary for governance networks to function *well* (cf. Lewis, 2011).

3. Research design and data collection methods

To investigate these issues we present an original comparative framework using case studies of three European cities - Birmingham (UK), Budapest (Hungary) and Frankfurt (Germany). These were chosen according to the most dissimilar cases logic to cover a wide geographic area with diverse national settings and historical development trajectories (Hantrais, 1999) (see Table 1).

Table 1. Political and administrative characteristics of case study cities

	BIRMINGHAM	BUDAPEST	FRANKFURT
Country	United Kingdom	Hungary	Germany
State structure	Unitary-centralised	Unitary-decentralised	Federal-decentralised
Public administrative tradition	Public interest	Rule-of-law with socialist cadre administration influence	Rule-of-law
Local government legal authority	Weak, traditionally service delivery oriented	Moderate, regular shifts between de- and re-centralisation	Strong
Local government fiscal authority¹	Moderate	Moderate	Strong
Role of the local level in energy systems governance²	Weak (app. 2%)	Moderate (app. 20%)	Strong (app. 35%)
Carbon emissions reduction target	60% by 2027 (1990 baseline)	40% by 2030 (15% compared to 2015 baseline)	app. 95% by 2050 (1990 baseline)

Sources: Copus et al., 2017; Kuhlmann and Wollmann, 2014; Loughlin et al., 2011; Swianiewicz, 2014

¹ Proportion of local government spending within the public sector, relative to national GDP.

² Proportion of energy produced locally relative to demand (including electricity, and domestic and industrial heat; primary fuels - gas, oil, coal - imported). Sources: BuCC, 2018; FCC, 2015; GC, 2013a

The policy focus is on the energy sector, more specifically strategy development and implementation for local sustainable energy production and distribution. Energy systems represent critical infrastructures on which many others depend, as well as key sites for climate change mitigation (Rockström et al., 2017). Moreover, there is a growing interest on the local level in developing decentralized energy projects such as combined heat and power (CHP) plants, waste-to-energy schemes or solar power plants (IEA, 2017; TC, 2015). These initiatives provide opportunities for local authorities and other local actors to enter the traditionally nationally organized energy regimes whilst also contributing to the reduction of local carbon-dioxide emissions.

The comparative study is structured as follows. First, network visualization and statistical measures of network structure (Grandjean, 2015; Prell, 2012) are used to compare the

energy transition networks in the cities. This provides a comparative overview on the state of network development (as of March 2017). Second, local contextual characteristics are assessed to uncover the possible causes of differences and/or similarities among the networks. The quantitative data is collected of organizations' participation in collaborative decision-making arenas involved in steering low-carbon energy transitions. The surveyed collaborative initiatives include committees, partnerships, roundtables, working groups and advisory boards. Membership data was obtained through web searches, the analysis of municipal publications and meeting minutes, and completed via semi-structured interviews with key informants.

The data were visualized as sociograms using Gephi software (www.gephi.org). Initially, two-mode or 'bipartite' network graphs were produced which included two different types of network nodes: member organizations and decision-making arenas. Organizations were connected through network ties to the arenas in which they participated. The two-mode network visualizations informed about the number and size of decision-making arenas, and on the levels of fragmentation and overlap among them. Links between arenas contributing to strategic decision-making and to implementation and delivery could also be visualized and identified (Figures 1, 2 and 3).

Figure 1. Two-mode network visualisations - Birmingham (whole network and core group)

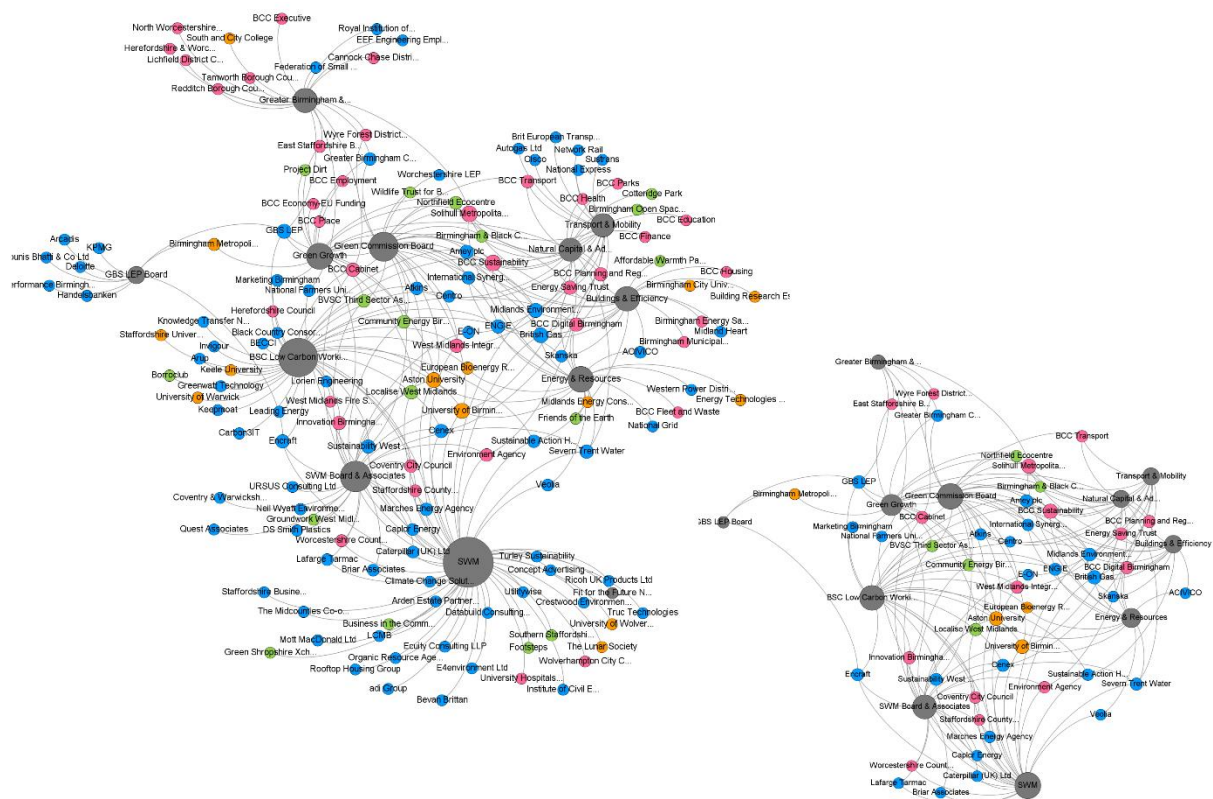


Figure 2. Two-mode network visualisations - Budapest (whole network and core group)

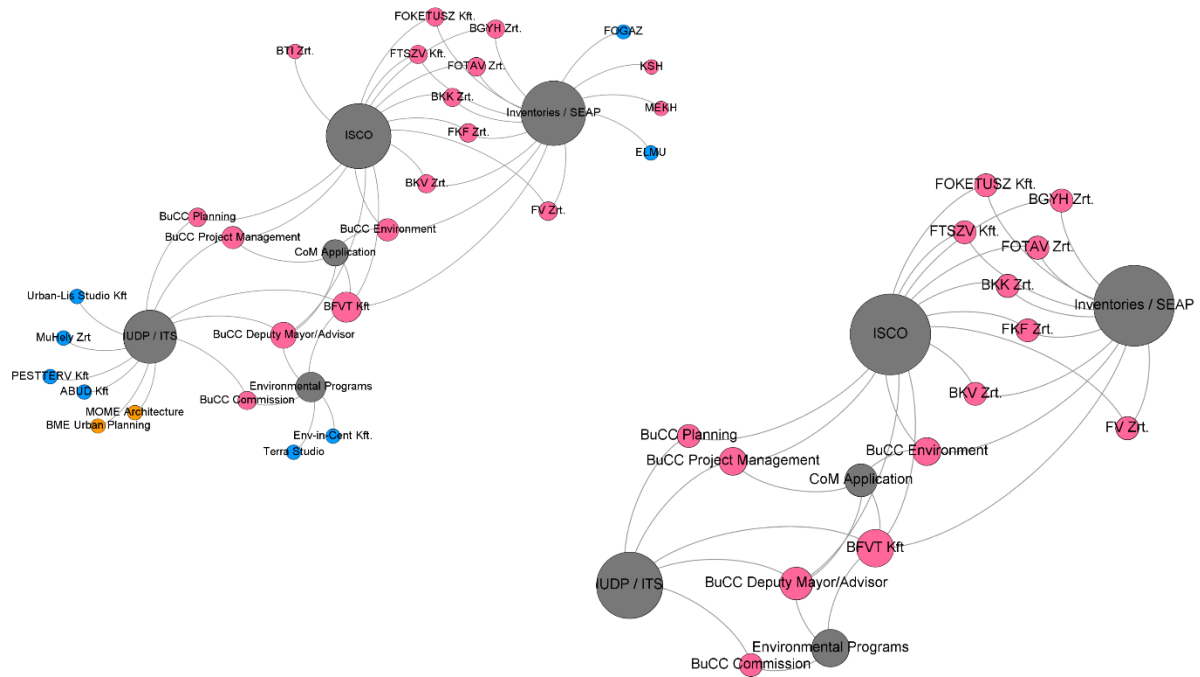
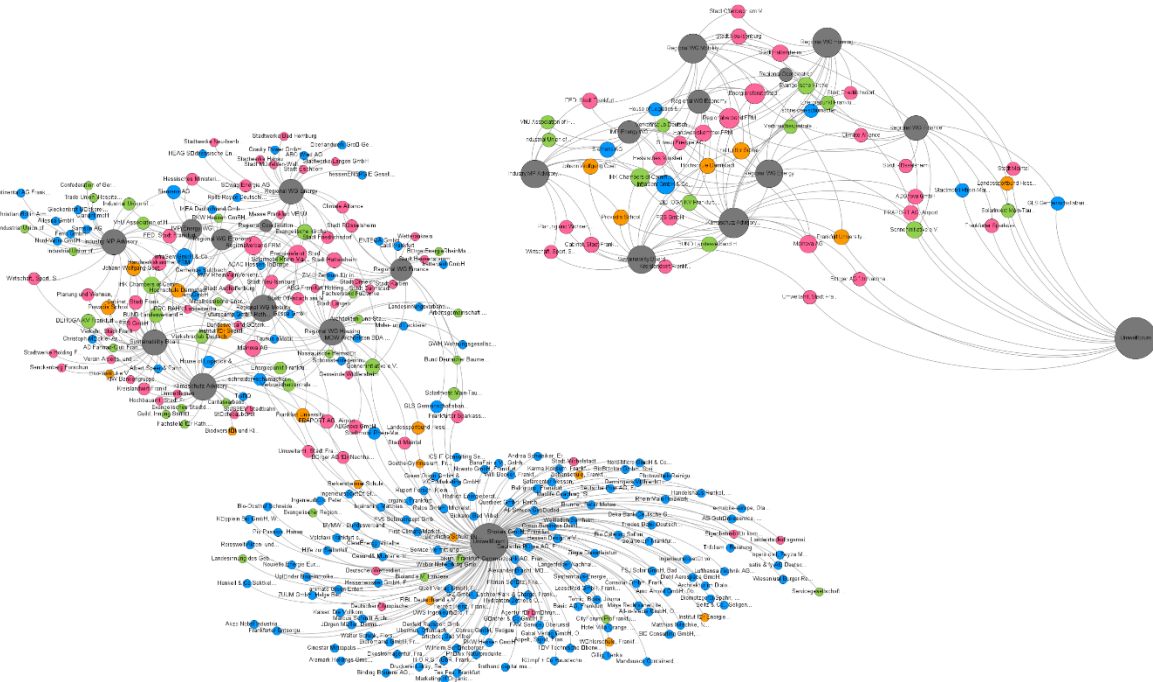


Figure 3. Two-mode network visualisations - Frankfurt (whole network and core group)



By eliminating the collaborative initiatives, one-mode network visualizations were created in a second step. Organizations were connected to one another based on their mutual membership in decision-making arenas. This allowed for directly visualizing and analyzing the links among network actors (Figures 4, 5 and 6).

Figure 4. One-mode network visualisations - Birmingham (whole network and core group)

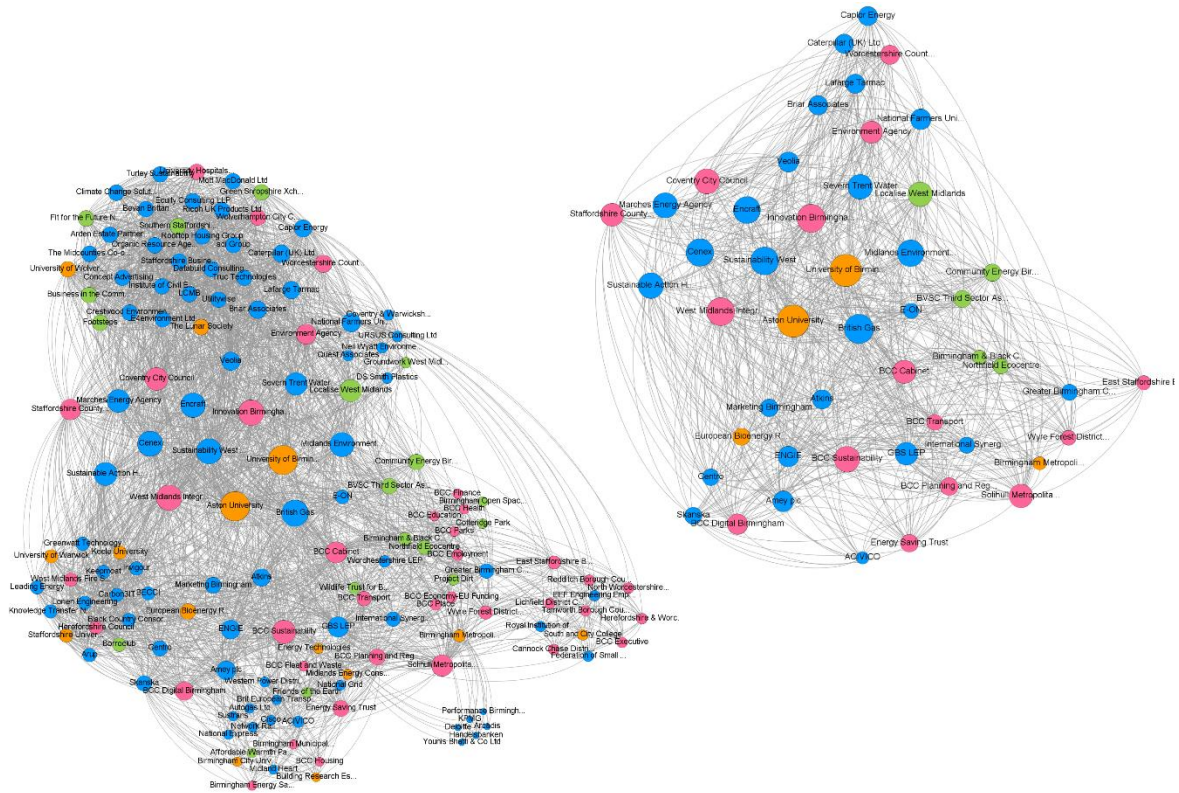


Figure 5. One-mode network visualisations - Budapest (whole network and core group)

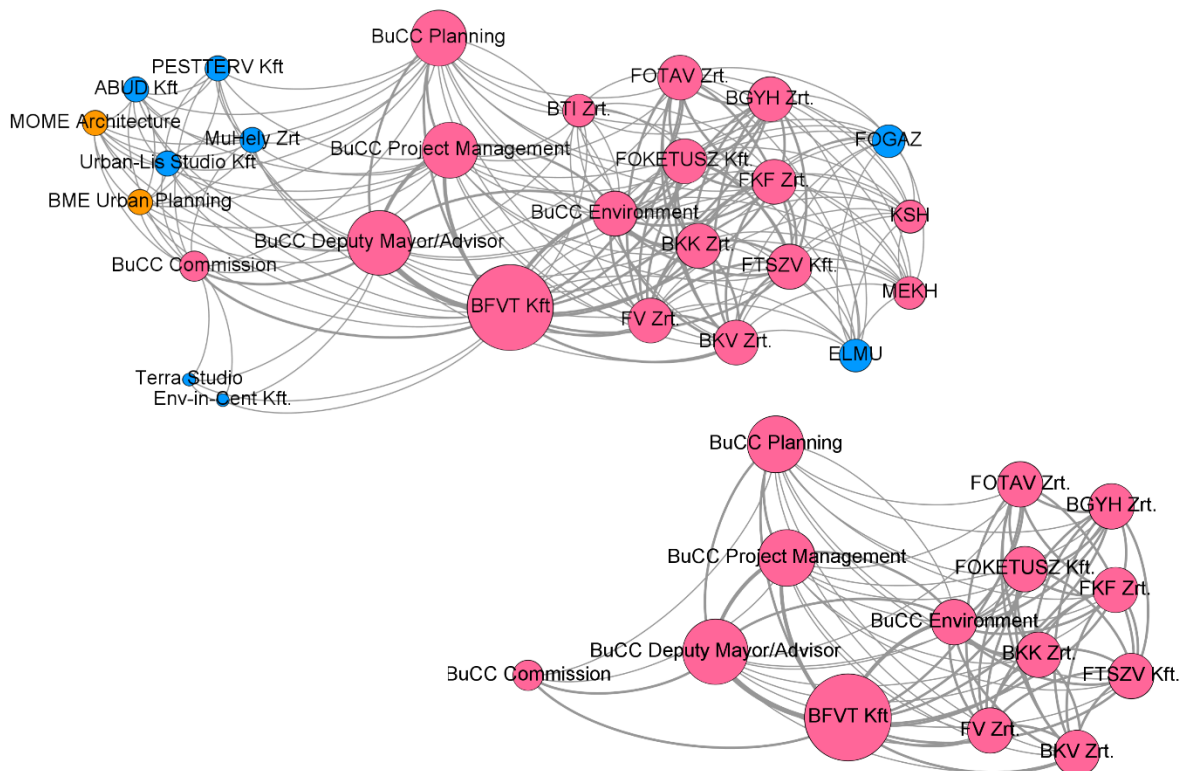
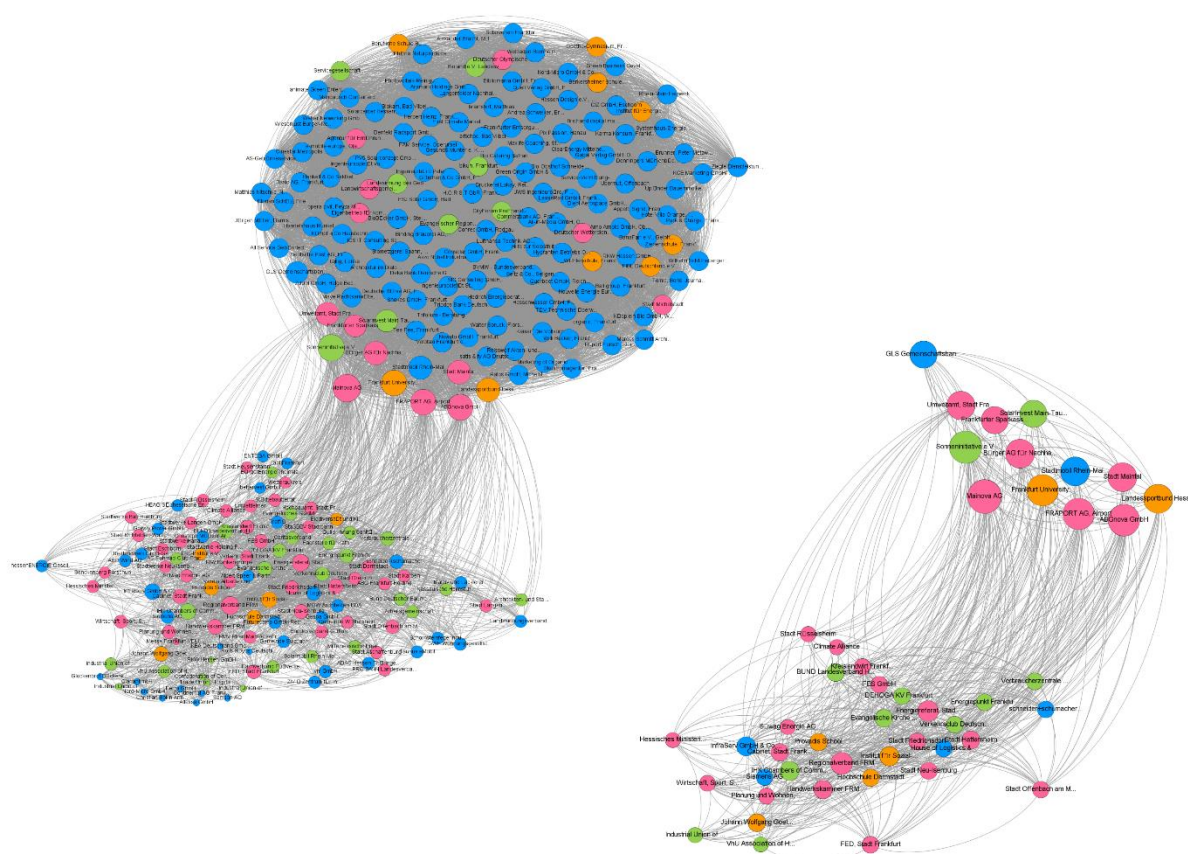


Figure 6. One-mode network visualisations - Frankfurt (whole network and core group)



Basic network statistics used in this study describe the whole network (size, density and centralization), as well as specific actors based on the positions they occupy within the networks (degree, betweenness and closeness centrality) (Table 2). The statistical measures were computed both for the whole networks, and their core groups (consisting of actors involved in at least two arenas).

Table 1. Network statistical measures for analysing structural characteristics of energy transition networks (Source: Prell, 2012)

NETWORK MEASURE	DEFINITION	INFORMATION PROVIDED
Network size	Number of nodes in the network.	Number of decision-making arenas and of the actors involved, used as proxy for outreach to stakeholders.
Density	Proportion of ties present in the network compared to the possible total number of ties.	Overlap between decision-making arenas in terms of membership, related to the interconnectedness of the network.
Centralisation	The extent (proportion) to which one actor in the network holds all ties present in the network.	Indicates actor groups centralised around another actor; to determine whether high density results from general interconnectedness,

		or from the presence of a few well-connected actors.
Degree centrality	Number of immediate contacts owned by any one actor, i.e. the number of ties/edges belonging to a node.	To identify the most well-connected actors who are involved in multiple arenas.
Betweenness centrality	Calculated on the basis of how many times an actor (node) sits on the shortest path between two unconnected actors.	To identify actors who connect separate groups and play a brokerage role in the network.
Closeness centrality	Measuring 'independence' of a node, calculated from the distance between actors; actors positioned to the shortest distance to others have higher scores.	To identify actors who have the greatest potential to influence the network processes.

Qualitative data were collected to verify the results of the network analyses, as well as to describe the local contexts in which the networks operated. Secondary data were obtained from municipal documents, reports, publications and meeting minutes. Primary data were generated through semi-structured interviews conducted with central actors in their own language. Respondents included actors from the public (local authority officials) and market (utility company managers) sectors as well as community and voluntary organizations (energy co-operatives). Between 9 and 13 interviews were conducted in each city. Interview transcripts were coded using NVivo. Categories for coding included: network actors, context description, collaboration constraints and drivers, collaboration among local authority departments, local energy transition narrative and network impact on energy transitions.

4. Comparative analysis of the energy transition networks of low-carbon energy transitions in Birmingham, Budapest and Frankfurt

The visualization and analysis of the energy transition networks in the case study cities reveals that Birmingham and Frankfurt have formalized collaborative initiatives. In Budapest, in contrast, multi-stakeholder collaboration was limited to semi-formal working groups which were responsible for producing documentation – published regularly – for policy and strategy development and implementation, and an advisory body which was under implementation at the time of data collection (Table 3).

Table 2. Basic network statistics of energy transition networks in the case study cities

STATISTICAL MEASURES	BIRMINGHAM	BUDAPEST	FRANKFURT
Whole network			
Type of network	Formal	Semi-formal	Formal
Network size	159	32	281

Arenas (collaborations)	11 (9+2)	5 (4+1)	11 (10+1)
Organisations (actors)	148	27	270
Number of connections	263	47	363
Network density (%)	2.1	9.5	0.9
Centralisation score	0.32	0.38	0.55
Core group			
Organisations (actors)	49 (33% of total)	14 (52% of total)	47 (17% of total)
Number of connections	164 (62% of total)	35 (73% of total)	140 (38% of total)
Network density (%)	9.5	20.5	8.5
Centralisation score	0.32	0.58	0.31

The structural analysis reveals a comparatively decentralized and polycentric network in Birmingham. It is characterized by high density and low centralization scores, and a populous core network relative to the total number of stakeholders (33%). The largest network was found in Frankfurt, but the core group is comparatively smaller involving only 17% of the whole network and has greater density than in Birmingham. This indicates a separation between the core of the Frankfurt network and its periphery. Thus, the core group has more potential to assume a leading role in influencing network processes and decisions compared to Birmingham. Network density measures were found to be lower in Frankfurt than in Birmingham, indicating somewhat less overlap between arenas in terms of membership – and by extension, responsibilities and tasks assigned to different arenas. A considerably smaller and weaker network was found in Budapest than either in Birmingham or Frankfurt. The Budapest network consists of a small number of arenas with only a few member organizations and is characterized by an absence of formalized collaborative initiatives. The high density score can be explained by its dependence on network size. There is a less apparent divide between the core and the periphery in terms of the number of actors and connections retained by the core group compared to the other two cases. This, coupled with the relatively small network size, indicates that the Budapest network is likely to be more closed and exclusive than either Birmingham's or Frankfurt's.

In terms of sectoral representation, the percentage of network actors belonging to the public, market, third sector or academia also shows significant variance (see Table 4).

Table 3. Sectoral representation among network actors in the case study cities

	BIRMINGHAM	BUDAPEST	FRANKFURT
Whole network			
Public % (inc. publicly owned companies)	24%	67%	21%
Market % (private businesses)	55%	26%	60%

Third % (voluntary organisations & citizens' groups)	12%	0%	13%
Academia % (inc. private research institutes)	9%	7%	6%
Core group			
Public % (inc. publicly owned companies)	31%	100%	51%
Market % (private businesses)	52%	0%	13%
Third % (voluntary organisations & citizens' groups)	10%	0%	23%
Academia % (inc. private research institutes)	6%	0%	13%

With the exception of Budapest, the cities show similarities in terms of the shares of different sectors at the network level. In Budapest, the influence of the public sector is overwhelming both in the whole network as well as in the core group, demonstrating a lack of integration of the market and third sector and academic institutions into decision-making. In Birmingham, sectoral shares remain mostly unchanged between the whole network and the core group, signaling a more apparent integration between the public and private sphere. The share of public sector organizations increases sharply in the core group in Frankfurt, indicating a more central role for the public sector in local energy transitions.

On the level of individual actors, three types of centrality scores were considered (Table 2). These reveal that in Birmingham, the network is dominated by organizations with a regional or national focus, i.e. academic institutions, private companies and business associations. Organizations with a distinct local focus, such as the Council Cabinet, Sustainability Team and Community Energy Birmingham, occupy important but less central positions. Due to high levels of integration and less apparent internal hierarchy between public sector bodies and externals, it may prove difficult for any one actor to assume the position of the transition manager in Birmingham.

In contrast, public sector bodies, utilities and community organizations (energy cooperatives) are among the most influential actors in Frankfurt's network. These include Mainova, the City Energy Agency, the Frankfurt-Rhein-Main Regional Authority or Sonneninitiative. The dominant form of market sector influence appears to be collective professional organizations and associations. As a result, Frankfurt City Council's Energy Agency is likely to be more successful in 'managing' local energy transitions.

In Budapest, actors with the highest centrality scores included the Municipal City Planning Agency, the Deputy Mayor for Urban Development and municipal departments responsible for EU funding management, indicating a potential disconnect between strategic decision-making, and implementation and monitoring activities undertaken by other less central actors. This situation, coupled with the absence of formal decision-making arenas, the relatively low number of actors involved in the network and the lack of integration between the public and private spheres, indicates the persistence of the traditional hierarchical

decision-making model in Budapest despite some interaction among stakeholders. As the relevant infrastructures and resources are managed by a small number of organizations with strong links to the public sector, the network-governance-based TM approach needs to be tailored accordingly.

5. Understanding variance: the role of the context

Section 4 demonstrates that all three cities have been engaging with the sustainable energy agenda for some time now. The development of strategies and policy priorities involved interaction among multiple actors. The collaborative fora within these networks could be regarded as embryonic 'transition arenas', and thus susceptible to the application of TM. However our analysis also shows differences in the structural features of the energy transition networks in each city. One explanation may be that there are important contextual differences which, as we noted earlier, are seldom considered in either the network governance or TM literatures. Thus, assessing the 'context' is necessary to determine whether TM can or should be applied in the cities, and if so in what way.

To undertake this assessment we draw on Torfing's (2005) observation that the emergence of network forms of governance is underpinned by three change factors: societal and organizational fragmentation, complexity in contemporary decision-making due to uncertainty and new societal dynamics related to a shift from 'government' to 'governance'. These factors are considered in terms of their impact on two network characteristics: the degree of integration between actors from different sectors; and the power relationships among the actors involved in the networks (Table 5).

Table 4. Contextual characteristics influencing network structure and process

CONTEXT	INTEGRATION	POWER RELATIONSHIPS
Societal and organisational fragmentation	Resource distribution between actors as a result of dispersion of authority (vertical) and form/extent of market liberalisation (horizontal).	Role of local actors in energy systems governance, and openness and opportunities for new (local) actors to join.
Complexity and uncertainties of low-carbon energy transitions	Urgency and the required degree of change in physical infrastructure and/or organisational structure to deliver carbon reduction targets.	Clear direction offering credibility for local low-carbon energy transitions (tangible targets; alignment between national, regional and local targets; division of responsibilities among different levels).
New societal dynamics and the historical development of the local sustainable energy agenda	Previous experience with collaborative, networked forms of governance.	Local authority steering and leadership, with continued presence in the network.

5.1 Societal and organizational fragmentation

Societal and organizational fragmentation refers to resource distribution vertically (among different organizational scales) and horizontally (among various actors from the public and

private sector and communities on each scale), and to the potential and role of local actors to influence energy systems and to facilitate their low-carbon transitions. Energy systems are typically nationally organized. Despite varying levels of authority and capacity over energy systems operation and management locally, energy policy-making and regulatory tasks are generally undertaken on higher organizational levels (i.e. national and EU governments) in each of our city cases.

Decentralized technologies (such as heat and power co-production (CHP), district heat and hot water networks, waste-to-energy schemes, and solar photovoltaic and thermal) and the promotion of energy efficiency (buildings, industrial processes, transport) have opened up windows of opportunities on the local level to influence the trajectory and pace of energy transitions. These emerging solutions can be linked to services typically offered by local authorities, including waste and sewage management, education and social housing, and to social agendas, such as reducing fuel poverty and joblessness. However, the ways in which strategies and projects are developed and delivered is shaped by organizational and resource fragmentation.

Decentralization in energy production and distribution in the UK has been relatively slow. Energy systems are dominated by central government bodies and national and international corporations (Devine-Wright and Wiersma, 2013). Local authorities, including Birmingham's, have had little or no leverage over energy systems policy, operation or supply for over half a century (Hawkey et al., 2013). Until recently local authorities were barred from obtaining energy supply licenses and owning or operating municipal energy companies (Webb et al., 2016). As a result, only 2% of the Birmingham's electricity and heat demand is generated locally (Lee et al., 2016), produced by a waste-to-energy plant and CHP feeding a city centre district heating network.

Difficulties with building, managing and operating energy systems locally arise from a lack of experience, and financial and human resources in local authorities in the UK. Consequently, distributed generation projects in Birmingham have historically been carried out by private sector companies (e.g. Veolia and Engie) through contractual relationships with the city council. In addition, the design of the UK energy markets favors large-scale production and centralized systems of distribution (Bolton and Foxon, 2013), inhibiting new (local) actors from entering the sector, and limiting community energy schemes' potential for growth (Community Energy Birmingham).

In Germany, energy systems remained relatively decentralized and characterized by a large number of actors, as well as the strong position of municipal utilities, formerly 'Stadtwerke' (Bayer, 2015). Causes include the energy regulation culture preceding the introduction of market competition (i.e. exclusive concession contracts with local authorities and demarcation agreements) (Hall et al., 2016), and the absence of major centralization efforts from the federal state. In Frankfurt, the local utility company Mainova is majority-owned by Frankfurt City Council (www.stadtwerke-frankfurt.de/beteiligungen). Mainova owns and operates the water, electricity, gas and extensive district heat infrastructure within the city limits, and acts as a supply company towards consumers. The high share of local energy production relative to demand (about 35%; FCC, 2015) however does not necessarily support the low-carbon energy transition: Mainova's local power plants burn fossil fuels (gas and coal).

Showing a clear difference between Birmingham's and Frankfurt City Council's capacity and capability to facilitate change in the energy sector is Frankfurt's success in mainstreaming block-type energy and heat cogeneration units which replicate the larger scale CHP technology to fuel housing or tower blocks (TC, 2015). This was supported by a local policy

to provide a fixed feed-in tariff for the energy fed into the local grid, and by Mainova taking up the role of the maintenance service provider for the installations. Via the ownership of Mainova, as well as a social housing company (ABG), Frankfurt City Council remains an influential actor in determining the city's energy future. Parallel to the Council's efforts, the federal level framework for energy transition ('Renewable Energies Act'; FGG, 2017) encourages small companies and citizen organizations to contribute to energy production. Consequently, several large solar power co-operatives (e.g. Sonneninitiative, Solarinvest Main-Taunus) started operating in and around Frankfurt, bringing new actors in the existing stakeholder network.

Energy systems and their governance in Budapest represent a mixed context compared to Birmingham and Frankfurt. Similarly to the UK, the management and operation of electricity and gas networks in Hungary is also dominated by national public bodies, and (mostly international) corporations (Zsebik, 2012). However, Budapest City Council owns utility companies responsible for district heating supply (FŐTÁV) and waste (FKF), water (Budapest Waterworks) and sewage (FCSM) management. Local CHP power plants feeding the district heating networks are owned by a private company (Budapest Power Plant). The utilities today operate as separate entities but were previously administered centrally under the country's communist regime. Despite the nearly three decades since the transfer of ownership from the central administration to the local authority, collaboration and cooperation among the utilities, as well as with the Municipality, remains underdeveloped.

On the national level, there is no major commitment for the further development of decentralized technologies in Hungary. Instead, carbon emissions mitigation relies on new low-carbon power plants (mainly nuclear and large-scale solar) and on expanding energy generation from biomass and geothermal sources (NGH, 2012; Zsebik, 2012). As a result, local energy priorities focus on improvements to the existing district heating network, and the expansion of waste-to-energy production (BuCC, 2017). These developments do not introduce new tasks or responsibilities into the remits of the municipal utility companies, and provide little or no room for new players to enter the energy sector in Budapest.

5.2 Complexity and uncertainties of low-carbon energy transitions

Our research found that the complexities and uncertainties of low-carbon energy transitions resulted in distinct local rationales developing in each city. These influenced the dominant perceptions of the necessity, nature and urgency of change needed. Relatively high emissions reduction targets with tight deadlines, requiring both technological (new infrastructure and assets to be built) and social (counteracting fragmentation to deliver new infrastructures) change, translated into higher levels of integration among network actors. Power relationships (between public sector bodies and externals) have been influenced by whether a clear direction was provided for local energy transitions. Indicators of a clear direction included tangible targets in terms of the contribution of the energy sector to overall carbon emissions reduction targets; alignment between national, regional and local targets; and a division of authority, responsibilities and tasks among the different organizational levels. These factors appear to be particularly important in lending credibility to local low-carbon energy ambitions.

In Birmingham, complexities arising from the absence of market pressure (i.e. the lack of a business case to implement decentralized energy projects) and social awareness (i.e. the lack of a wide-spread concern over the security of supply due to historical accessibility of fossil fuel reserves) has led to the framing of sustainability transitions mainly through ideological and party-political lenses. In the British political context, dominated by regular shifts between left-wing Labour and right-wing Conservative leadership with largely opposing

views on energy and society, this is especially problematic. Thus, despite a broad consensus on long-term carbon emissions reduction goals, commitments appear to be superficial and outcomes uncertain, including the expected contribution of the energy sector. The consequence is a lack of clarity about the relationship between strategic goals, supporting policies and implementation both locally and nationally. Uncertainty is also fueled by the absence of a detailed national energy strategy which inhibits the alignment of goals and responsibilities across the national, sub-national and local levels. Birmingham's ambitious carbon emission reduction goal (60% by 2027) is in fact not backed up by support from the national level (GC, 2013a). The expected contribution of developing decentralized energy infrastructures to achieving this target remains vague (GC, 2013b). This contributes to higher levels of integration with the market sector and more horizontal relationships among actors in Birmingham's network.

German energy policy has a traditional focus on reducing uncertainties in energy demand and in the reliability of energy imports, originating in the oil crises in the 1970s and 1980s. Strict measures were developed and implemented to reduce demand through improving efficiency in the production of heat and electricity and via insulating buildings (Morris and Pehnt, 2012). Fossil-fuel free production has been at the centre of attention and investment for decades. Environmental movements have historically been relatively strong compared to other European countries, and their political representation (Alliance 90/The Greens) gained support quickly. Frankfurt (and the Frankfurt-Rhein-Main region) is a traditional stronghold of The Greens who have been part of the ruling coalitions of the city continuously since 1990. This continuing influence contributed to managing the complexity of low-carbon energy transition by building cross-party support for the policy. It also shaped the thinking around the necessity of social change alongside the technological by encouraging a move towards a more democratic energy supply system with considerable contribution from citizens as 'prosumers' (producer-consumers). Thus, while the majority of conventional large-scale electricity production is owned by four big companies (EnBW, E.ON, RWE and Vattenfall) in Germany, the ownership of renewable generation is dominated by citizens and community organizations (nearly half of the total), industry self-supply and project developers and investment banks (Bayer, 2015).

In contrast to Birmingham and the UK, energy transition in Germany is considered in its own right rather than simply as part of a broader carbon emissions reduction agenda. The aligned federal, state (Hesse) and local-regional (Frankfurt and Frankfurt-Rhein-Main) emissions reduction targets are estimates that the carbon-neutral transformation of the energy infrastructure can deliver: approximately 80-95% by 2050 (FGG, 2017). However, the energy-intensive economy acts as a barrier to transitions both on the federal level as well as in Frankfurt. Due to difficulties with directly engaging market actors in the energy transition agenda of the city, a dominant rationale developed that sees industry as customers with a demand for energy rather than partners in reducing emissions. This results in lower integration between the public sector and market actors, a relatively strong position for community initiatives (energy co-operatives), and network-internal hierarchy between the public sector and externals in Frankfurt's energy governance network.

At the period which was foundational for Birmingham and Frankfurt in developing an interest in sustainable development (1970s to 1990s), Budapest (and Hungary) had to deal with the complexities and uncertainties arising from restructuration of society (reinstating the democratic order), the economy (from centralized state communist to liberal capitalist model) and of the politico-administrative system (decentralization). As a consequence, sustainable development has been interpreted in its broadest sense along economic, social and environmental dimensions (Kerekes, 2006). The shift from communism to capitalism was

seen as a means to deliver on the ambitions along all three dimensions: it was expected to enhance the well-being of citizens by reinstating democracy, to produce economic growth through a shift from centrally coordinated economic activity to market competition, and to address concerns over environmental degradation and pollution through abandoning heavy industries (BuCC, 2003). The environmental agenda emphasized the role of mitigating the impacts of environmental degradation resulting from industrial processes instead of reducing carbon-dioxide emissions specifically (Kerekes, 2006).

Initial successes (e.g. the dismantling of much of the carbon-intensive heavy industry resulted in a carbon saving of 43% by 2009 compared to the 1987 baseline; NGH, 2012) contributed to the development of a rationale that action directed explicitly at emissions mitigation was not required, and further modernization would deliver the carbon reduction commitments. Thus, the decarbonization of energy infrastructures has either been left to the market, or been driven by the politics of the day – for example, through the construction of a new nuclear power plant built from Russian interstate loan (Energiaklub, n.d.). There is little encouragement for investment into renewables for citizens or for-profit investors; in fact, their participation in energy production is often actively discouraged. The environmental tax on solar panels due to the embedded carbon used in the production process, the low feed-in tariffs and the government-dictated artificially low energy unit price are examples of such direct and indirect discouragement (NGH, 2015).

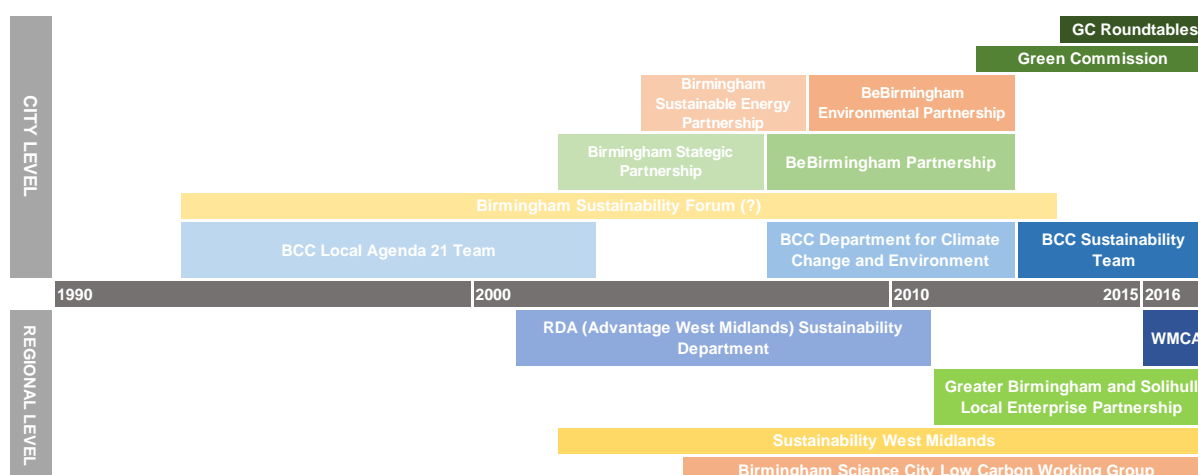
In this energy policy context dominated by party politics and market mechanisms rather than strategic leadership, Budapest City Council decided not to take up the complex challenge of restructuring local energy systems and the associated organizational landscape. Instead, the focus is on facilitating win-win situations where urban development projects (driven by grant opportunities and national political priorities) also contribute to reducing emissions. This translates into system improvements to existing infrastructure (e.g. district heating networks and public lighting), and the energy-efficient modernization of the aged and/or low-quality housing blocks (BuCC, 2017). Such initiatives require little cross-sectoral collaboration or integration among actors from the public and market sphere and civil society. Traditional hierarchical decision-making processes appear to persist more than either in Frankfurt or Birmingham.

5.3 New societal dynamics and the historical development of the local sustainable energy agenda

In terms of changing societal dynamics along the historical development of the local sustainable energy agenda, higher levels of integration among actors from different sectors was found in cities which had experience in working collaboratively with stakeholders in various domains. Local low-carbon transition agendas both in Birmingham and Frankfurt developed as a continuation of early sustainable development efforts in the 1990's. In Budapest, this experience was lacking.

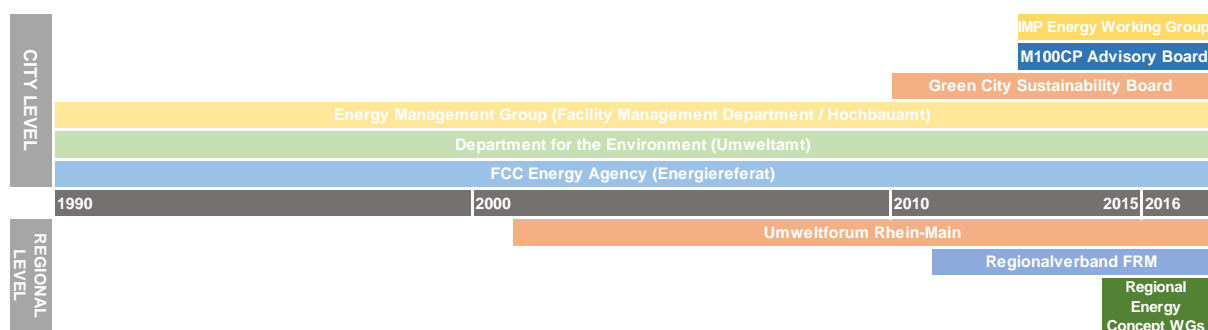
Birmingham City Council started engaging with actors external to the local authority to address pressing problems around urban development and regeneration of the inner city areas (Figure 7). Public-private partnerships (Be Birmingham) started operating from the nineties, initially focusing on implementation and project delivery. The low-carbon agenda, initially expressed as making Birmingham 'cleaner, greener and safer' was at that time part of the remit of Be Birmingham. Later on, several other initiatives were set up to support low-carbon development.

Figure 7. Low-carbon transition governance initiatives in Birmingham



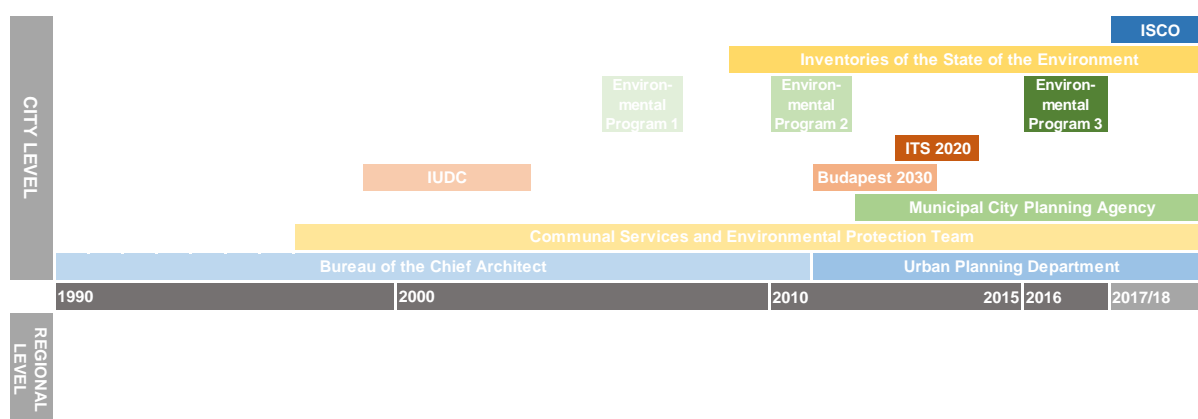
In Frankfurt (Figure 8), the Municipality's Energy Agency was established in 1990 to provide assistance with implementation and project delivery relevant to the City's commitment to sustainability through the Climate Alliance (www.climatealliance.org). Despite a case-by-case engagement with external stakeholders involved in specific projects, formal collaborative initiatives started only in the early 2000's (Environment Forum / Umweltforum; www.umweltforum-rhein-main.de) and focused mainly on implementation. Initiatives aimed at influencing strategy development and policy making followed from 2010 with the Sustainability Board supporting Frankfurt's application for the European Green Capital award.

Figure 8. Low-carbon transition governance initiatives in Frankfurt



In Budapest (Figure 9), semi-formal collaborative initiatives were organized around the production of municipal documents, for example the 'Budapest 2030 Plan', the 'City Environmental Programs' or 'Inventories of the State of the Environment'. In implementation, one collaborative decision-making arena (Advisory Board) is expected to be established through the ISCO ('Innovation Services Company') concept uniting the municipal utility companies to drive innovative initiatives.

Figure 9. Low-carbon transition governance initiatives in Budapest



Power relationships within the networks are influenced by whether the coordination of the low-carbon agenda and of the stakeholder networks were assigned to any one organization; that body's position in the organizational landscape relative to the traditional locus of decision-making power; and its (continued or periodic) presence in the energy transition network over time. Organizations tasked with steering network processes - in effect, the Transition Manager in a TM strategy - were found in Birmingham (Sustainability Team), Frankfurt (Energy Agency) as well as Budapest (Municipal City Planning Agency - BFVT). Despite its local authority ownership, the Planning Agency in Budapest operates as an external organization. The Sustainability Team and the Energy Agency both function as departments of the local authorities. However, in contrast to the Energy Agency, the Sustainability Team was established relatively recently in 2012 as a successor to the Department for Climate Change and the Environment. Shortly after the data collection for this study, the Sustainability Team was abolished in 2017. Budapest's City Planning Agency's opportunities to steer the network and influence the outcomes (policy, strategies and projects) was limited due to its position external to the City Council. In Birmingham, the Sustainability Team encountered difficulties in influencing governance processes both within the local authority as well as in the energy transition network due to its relatively short life-span, the Council's periodic interest in low-carbon transitions and the resulting occasional presence in the network. In contrast, Frankfurt's Energy Agency appears to be in a good position to steer the local network and to influence decision-making within the Council.

6. Conclusion and Policy Implications

This article analyzes the opportunities and limitations for networked forms of governance to facilitate low-carbon energy transitions in cities, and specifically set out to establish (1) whether and in what form energy transition networks exist in European cities and (2) the extent to which they provide a basis for utilizing and/or refining TM strategies. Our research into Birmingham, Budapest and Frankfurt demonstrates that networks whose remit included issues related to sustainable energy have existed for decades in all three cases. The energy transition networks found in the different cities exhibit significant variance in terms of extent and role in relevant local decision-making processes. In contrast, carbon emissions reduction rates published by the local authorities show a relatively consistent picture across the three cases, with Frankfurt's per capita emissions remaining at the highest levels according to the currently available figures (BCC, n.d.; BuCC, 2017; FCC, 2015). This appears somewhat surprising in light of the network analyses and results presented in this article which demonstrated that Frankfurt's network topography is by far the closest to what the TM model prescribes (i.e. governance network developing from multi-stakeholder decision-making arenas, steered by a transition manager). Thus, it is likely that carbon

emissions reduction has been so far driven by the global tendency of restructuring urban economies by replacing industry and manufacturing with the less carbon-intensive sectors of services and finance in our city cases (cf. Sassen, 2011).

Despite the apparent limitations of local governance networks to deliver on urban low-carbon ambitions in the contemporary political and economic environment, our research indicates that certain niche roles that networks may play are likely to be more effective in some places and less so in others. This in turn highlights the need for better understanding the relationship between the networks and the context and the ways in which it constrains and enables the development of different types of governance processes. Rather than privileging 'networks' as the key intervention in TM, the research reported here reveals the possibilities and roles that networks and transition managers can play in specific contexts. Implementing TM cannot be considered independently of the existing networks and their context, but rather it is an intervention into locationally-specific settings. Consequently, it is essential that the design of the intervention is based upon sound analysis.

This article demonstrated that network visualization and analysis are useful tools to build knowledge about existing networks, the actors involved in these, as well as their relationships to one another. Differences in terms of structural characteristics among the energy transition networks in our case study cities highlighted the importance of considering local contextual factors and the constraints and opportunities these pose on network governance to function 'well' (i.e. to deliver the promised benefits). Various structural and cultural factors (as summarized in Table 5) contribute to developing and maintaining distinct path dependencies and disjunctions in each city: the transition from communism in Budapest/Hungary, the centralization and marketisation of energy supply in Birmingham/UK and energy security priorities and environmental movements in Frankfurt/Germany.

Despite the differences, there is scope for some generalization: the empirical evidence points to the significance of the structural position in the energy network of any 'transition manager' organization. Our study indicates that assigning the role of the transition manager to a local authority body has clear benefits (cf. Hodson and Marvin 2010b). One reason that why this is important is the difference between network *influence* and decision-making *authority*. Ultimately, it is the local government that has the authority and mandate to oversee the development of a city, to produce strategic plans and to deliver them. Besides the leadership from local authorities, developing a common voice and direction for transitions in the public sector and within the local authority, as well as with agencies and utilities – relevant to energy transitions – also seems necessary to deliver on energy transition goals.

Yet while the TM approach proposes the creation of new transition arenas, we found that interventions other than *de novo* institution-building are likely to be more appropriate in cities where sustainability networks already exist - for example strengthening or redesigning existing collaborative initiatives. Birmingham represents a case with a history of network governance in various policy domains, where energy transition is considered indirectly as part of a broader carbon emissions reduction agenda. Here, one of the most important issues to consider is the expected contribution of the energy sector to the emissions reduction targets in order to assign this part of the network a more defined goal. This could help reduce the coordination problems that result from the large network size, high levels of integration among the actors, the more horizontal power relationships resulting from the periodic commitment of the local authority to prioritize the low-carbon agenda. In Frankfurt the hierarchical relationship between the public sector bodies and the rest of the network led to an alienation of industry and corporate actors which are responsible for a large proportion of carbon emissions but largely refrain from contributing to the mitigation plans and action.

Thus, the key challenge here is understanding how to better engage with the market sector, specifically energy-intensive industry and manufacturing. Some initial progress has already been made (for example, through the Energy Agency's involvement in the Frankfurt Industry Masterplan negotiations) but targets for energy saving from industrial processes remain unclear and voluntary. Budapest's network is weak and obscure due to the lack of formalized collaborative initiatives. Plans to set up formal decision-making arenas which could provide space for learning about collaboration regularly fail – for example, the ISCO has still not been set up despite being under consideration since 2014. Networks generally have a negative connotation and are associated with corruption, but improving transparency and formalizing some of the existing working groups (for example those producing annual monitoring reports) could provide space for learning about the potential benefits of more collaborative working. Project-based collaborations have been more successful in the past (e.g. the geothermal heat system for Zoo buildings using waste-heat from the neighboring Szechenyi Thermal Baths), highlighting an opportunity to improve integration across the energy transition network and to provide space for new actors to join.

Finally, not all transition arenas are created equal. However, there is a lack of discussion in the TM literature on the diversity of roles that different arenas may play in the decision-making process as a whole. Considering different options regarding the role of transition arenas in the decision-making process thus could also be beneficial to better exploit local opportunities for governing low-carbon transitions. Information exchange as a dominant mechanism for arena development has been found in all three of our city cases. Certain parts of the energy networks in Birmingham (Sustainability West Midlands) and Frankfurt (Environmental Forum / Umweltforum) served mainly for professional networking, relationship-building and resource-pooling. Expert groups have been involved in Frankfurt (Climate Protection Advisory Group / Klimaschutzbeirat) and to some extent in Budapest (Budapest 2030 Plan, Budapest Climate Change Strategy) for advice and consultation. In some cases in Birmingham transition arenas have been set up to provide space co-producing policy, guidelines or strategies (Green Commission and its Roundtables). This more active form of stakeholder engagement was not present in either Frankfurt or Budapest. Our research thus highlights the need to open up a discussion on how these different types of network processes, and various combinations of them, can best contribute to low-carbon energy transitions in different cities. For example, while the legal framework hinders the development of transition arenas tasked with co-producing policy and interventions in Budapest, it does allow for setting up collaborative governance initiatives to provide expert advice and to bring in specialist knowledge to support decision-making. Similarly, improved information exchange among local authority departments in Birmingham could lead to developing a more unified local authority position on the issue of carbon emissions reduction.

In conclusion, the empirical data collected on local governance networks in Birmingham, Budapest and Frankfurt revealed a need for more emphasis on *context* and *diversity* to better understand to potential of TM and other network-governance-based approaches to contribute to low-carbon transitions. We demonstrated that the local patterns of societal and organizational fragmentation, the perceived complexity and uncertainties of low-carbon energy transitions, and changes in terms of societal dynamics and their impact on the historical development of the local sustainable energy agenda have implications for the nature and extent of integration among societal actors, as well as for the power relationships among them. In turn, these factors influence the options for networked forms of governance to contribute to low-carbon energy transitions in diverse urban settings. TM-backed interventions therefore need to consider these locationally specific factors (and existing

networks) in order to develop locally appropriate responses to the challenges that sustainable energy transitions pose on cities and their governance.

References

- Bai, X., Dawson, R.J., Ürge-Vorsatz, D., et al (2018). *Six research priorities for cities and climate change*. Nature Publishing Group.
- Bayer, E. (2015). Report on the German power system. *Agora EnergieWende*. Available from www.agora-energiewende.de/en/publications/report-on-the-german-power-system [Accessed: 18/02/2019].
- BCC (n.d.). *Energy and Carbon Reduction*. Published by Birmingham City Council. Available from www.birmingham.gov.uk/info/20015/environment/260/energy_and_carbon_reduction [Accessed 18/02/2019].
- Bolton, R., Foxon, T.J. (2013). Urban Infrastructure Dynamics: Market Regulation and the Shaping of District Energy in UK Cities. *Environment and Planning A*. 45, 2194–2211.
- Börzel, T. (2010). European governance: negotiation and competition in the shadow of hierarchy. *JCMS: Journal of Common Market Studies*. 48, 191–219.
- Broto, V. C. (2017). Energy landscapes and urban trajectories towards sustainability. *Energy Policy*, 108, 755-764.
- BuCC (2018). *Budapest Klímastratégiája*. Published by Budapest City Council. Available from budapest.hu/Documents/klimastrategia/Bp_Klimastrategi%C3%A1ja_vegleges_KGY%20elfogadott.pdf [Accessed 18/02/2019].
- BuCC (2017). *Budapest Környezeti Programja 2017-2021*. Published by Budapest City Council. Available from http://budapest.hu/Documents/BKP_2021_0503.pdf [Accessed 18/02/2019].
- BuCC (2003). *Budapest Városfejlesztési Konceptió - Összefoglaló*. Published by Budapest City Council. Available from http://www.urbanisztika.bme.hu/segedlet/bp_fuzet/Urban-Development-Concept-of-Budapest.pdf [Accessed 18/02/2019].
- Bulkeley, H., Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the institute of British geographers*. 38, 361–375.
- Bulkeley, H.A., Broto, V.C., Edwards, G.A.S. (2015). *An Urban Politics of Climate Change: Experimentation and the Governing of Socio-Technical Transitions*. Routledge.
- Coenen, L., Truffer, B. (2012). Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. *European Planning Studies*. 20, 367–374.
- Copus, C., Roberts, M., Wall, R. (2017). *Local Government in England: Centralisation, Autonomy and Control*. Springer.
- Coutard, O. (2004). Urban space and the development of networks: A discussion of the “splintering urbanism” thesis, in: *Sustaining Urban Networks*. Routledge, 64–80.
- Devine-Wright, P., Wiersma, B. (2013). Opening up the “local” to analysis: exploring the spatiality of UK urban decentralised energy initiatives. *Local Environment*. 18, 1099–1116.

- Energiaklub (n.d). *Paks Nuclear Plant*. Energiaklub Climate Policy Institute. Available from energiaklub.hu/en/topics/paks-nuclear-plant [Accessed 18/02/2019].
- FCC (2015). *Frankfurt am Main: Masterplan 100 % Climate Protection*. Published by Frankfurt City Council. Available from [www.frankfurt.de/sixcms/detail.php?id=3081&_ffmpar\[_id_inhalt\]=30940019](http://www.frankfurt.de/sixcms/detail.php?id=3081&_ffmpar[_id_inhalt]=30940019) [Accessed 18/02/2019].
- FGG (2017). *Erneuerbare-Energien-Gesetz 2017 - Renewable Energies Act 2017*. Published by the Federal Government of Germany. Available from www.erneuerbare-energien.de/EE/Redaktion/DE/Standardartikel/EEG/eeg-2017.html [Accessed 18/02/2019].
- GC (2013a). *Birmingham's Green Commission. Building A Green City*. Published by the Green Commission of Birmingham City Council.
- GC (2013b). *Birmingham's Green Commission. Carbon Roadmap*. Published by the Green Commission of Birmingham City Council.
- Grandjean, M. (2015). *GEPHI – Introduction to network analysis and visualization*. Available from www.martingrandjean.ch/gephi-introduction/ [Accessed 18/02/2019].
- Hajer, M. (2003). Policy without polity? Policy analysis and the institutional void. *Policy Sciences*. 36, 175–195.
- Hall, S., Foxon, T.J., Bolton, R. (2016). Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research & Social Science*. 12, 5–15.
- Hantrais, L. (1999). Contextualization in cross-national comparative research. *International Journal of Social Research Methodology*. 2, 93–108.
- Hawkey, D., Webb, J., Winskel, M. (2013). Organisation and governance of urban energy systems: district heating and cooling in the UK. *Journal of Cleaner Production*. 50, 22–31.
- Hodson, M., Marvin, S. (2010a). *World Cities and Climate Change: Producing Urban Ecological Security*. Open University Press.
- Hodson, M., Marvin, S. (2010b). Can cities shape socio-technical transitions and how would we know if they were? *Research Policy*. 39, 477–485.
- IEA (2017). *Cities lead the way on clean and decentralized energy solutions*. Available from www.iea.org/newsroom/news/2017/april/cities-lead-the-way-on-clean-and-decentralized-energy-solutions.html [Accessed 18/02/2019].
- Kemp, R., Loorbach, D., Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. *The International Journal of Sustainable Development & World Ecology*. 14, 78–91.
- Kerekes, S. (2006). Fenntarthatóság Közgazdasági Értelmezése, in: Bulla, M., Tamás, P. (Eds.), *Fenntartható Fejlődés Magyarországon, Stratégiai kutatások – Magyarország 2015*. Új Mandátum Könyvkiadó, 196–211.
- Kern, K., Alber, G. (2009). Governing climate change in cities: modes of urban climate governance in multi-level systems, in: *The International Conference on Competitive Cities and Climate Change*, Milan, Italy, 9-10 October, 2009. 171–196.
- Khan, J. (2013). What role for network governance in urban low carbon transitions? *Journal of Cleaner Production*. 50, 133–139.

- Klijn, E.H., Koppenjan, J. (2015). *Governance networks in the public sector*. Routledge.
- Klijn, E.-H., Koppenjan, J. (2012). Governance network theory: past, present and future. *Policy & Politics*. 40, 587–606.
- Kuhlmann, S., Wollmann, H. (2014). *Introduction to comparative public administration: Administrative systems and reforms in Europe*. Edward Elgar Publishing.
- Lachman, D.A. (2013). A survey and review of approaches to study transitions. *Energy Policy*. 58, 269–276.
- Lachman, D.A., Panday, M.R., Ferrier, D.J. (2018). Context-driven transition management as a necessary vehicle for sustainable urban futures in Suriname, in: *Co-Creating Sustainable Urban Futures*. Springer, 327–348.
- Lee, S.E., Quinn, A.D., Rogers, C.D.F. (2016). Advancing City Sustainability via Its Systems of Flows: The Urban Metabolism of Birmingham and Its Hinterland. *Sustainability*. 8, 220.
- Lewis, J.M. (2011). The Future of Network Governance Research: Strength in Diversity and Synthesis. *Public Administration*. 89, 1221–1234.
- Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance*. 23, 161–183.
- Loorbach, D., Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures*. 42, 237–246.
- Loughlin, J., Hendriks, F., Lidström, A. (2011). *The Oxford handbook of local and regional democracy in Europe*. OUP Oxford.
- Morris, C., Pehnt, M. (2012). *Energy Transition: The German Energiewende*. Heinrich Böll Stift.
- Nagorny-Koring, N.C., Nohta, T. (2018). Managing urban transitions in theory and practice - The case of the Pioneer Cities and Transition Cities projects. *Journal of Cleaner Production*. 175, 60–69.
- Nevens, F., Frantzeskaki, N., Gorissen, L., Loorbach, D. (2013). Urban Transition Labs: co-creating transformative action for sustainable cities. *Journal of Cleaner Production*. 50, 111–122.
- NGH (2015). 2011. évi LXXXV. törvény a környezetvédelmi termékdíjról. Published by the 'Nemzeti Gadasági Hivatal' of Hungary. Available from njt.hu/cgi_bin/njt_doc.cgi?docid=138957.284236 [Accessed 18/02/2019].
- NGH (2012). Nemzeti Energiestratégia 2030 - National Energy Strategy 2030. Published by the 'Nemzeti Gadasági Hivatal' of Hungary. Available from 2010-2014.kormany.hu/download/4/f8/70000/Nemzeti%20Energiastrat%C3%A9gia%202030%20teljes%20v%C3%A1ltozat.pdf [Accessed 18/02/2019].
- Prell, C. (2012). *Social network analysis: History, theory and methodology*. Sage.
- Rittel, H.W., Webber, M.M. (1973). Dilemmas in a general theory of planning. *Policy Science*. 4, 155–169.
- Rockström, J., Gaffney, O., Rogelj, J., et al (2017). A roadmap for rapid decarbonization. *Science*. 355, 1269–1271.

- Roorda, C., Wittmayer, J. (2014). Transition management in five European cities—an evaluation. *DRIFT, Erasmus University Rotterdam, Rotterdam*.
- Rutherford, J., Coutard, O. (2014). Urban energy transitions: places, processes and politics of socio-technical change. *Urban Studies*. 51, 7, 1353-1377.
- Sassen, S. (2011). *Cities in a world economy*. Sage Publications.
- Skelcher, C. (2007). Democracy in Collaborative Spaces: Why Context Matters in Researching Governance Networks, in: Marcussen, M., Torfing, J. (Eds.), *Democratic Network Governance in Europe*. Palgrave Macmillan UK, 25–46.
- Swianiewicz, P. (2014). An empirical typology of local government systems in Eastern Europe. *Local Government Studies*. 40, 292–311.
- TC (2015). *Maximising Europe's Low Carbon Activities*. Published by Transition Cities, Climate KIC. Available from eit.europa.eu/interact/bookshelf/maximising-europe%E2%80%99s-low-carbon-activities-moving-individual-projects-challenge [Accessed 18/02/2019].
- Torfing, J. (2005). Governance network theory: towards a second generation. *European Political Science*. 4, 305–315.
- Wittmayer, J.M., Loorbach, D. (2016). Governing transitions in cities: fostering alternative ideas, practices, and social relations through transition management, in: *Governance of Urban Sustainability Transitions*. Springer, 13–32.
- Wolfram, M., Frantzeskaki, N. (2016). Cities and systemic change for sustainability: Prevailing epistemologies and an emerging research agenda. *Sustainability*. 8, 144.
- Zsebik, A. (2012). *Energiapolitika*. Available from www.energia.bme.hu/letoeltesek/326-letoeltesek-energiapolitika-bmegeenmeehttp://www.energia.bme.hu/munkatarsak-menu/75-dr-zsebik-albin?lang= [Accessed 18/02/2019]